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ABSTRACT

This pilot study was designed with four general objectives: (1) improving problem-solving strategies through the use of calculators; (2) determining the most effective timing for introducing calculators; (3) enhancing student interest in mathematics as a result of using calculators; and (4) identifying possibilities for further investigation. The main question was "Which of the basic skills in problem solving in elementary school mathematics can be developed through the use of the calculator?" Seven basic skills needed in problem solving were identified. The subjects were in grade three and grade five in each of two schools. One school became the experimental (calculator) group, and the other served as a control. Both schools followed the same mathematics curriculum guidelines and used the same text series. Results of the study indicate support for the use of calculators in developing certain basic skills in problem solving, with indications that further investigations are needed. Among the appendices are copies of the pretest, attitude scales, and a posttest used with both grade levels; teacher memos; suggested guidelines; record sheet forms; and selected samples of student-created problems. (MP)

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PROBLEM SOLVING WITH CALCULATORS IN ELEMENTARY SCHOOL MATHEMATICS

Report to The Protestant School Board of Greater Montreal

by

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McGILL UNIVERSITY

with the assistance of

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1981 - 06 - 30

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1. INTRODUCTION

1.1 Objectives:

The research project was designed as a pilot study with four general objectives:

- improving problem solving strategies through the use of calculators;
- determining the most effective timing for introducing calculators;
- enhancing student interest in mathematics as a result of using calculators;
- identifying possibilities for further investigation.

1.2 Question:

Specifically these objectives yielded the research question:

> Which of the basic skills in problem solving in elementary school mathematics can be developed through the use of the calculator?

1.3 Definition of Term

In order to identify the basic skills in problem solving, it was necessary to develop a taxonomy of problem solving skills. Several relevant models were considered, including Bloom's Taxonomy of Educational Objectives, and from these models, the following schema was produced:

Basic Skills Needed in Problem Solving Situations:

1. Practise in computation
2. Identifying patterns and decoding
3. Guess and test; estimate; round off
4. Choose operations in one-step word problems; two-step; multiple-step
5. Restate problems with missing or irrelevant information
6. Organize information using pictures, diagrams, lists, graphs, models, experiments
7. Plan a strategy

It should be noted that this interpretation of problem solving does not reflect that of the present elementary mathematics text series which seem to present mainly story problems and routine exercises.

In summary, this study investigates whether the calculator can facilitate the development of any of the seven basic skills identified above.

2. REVIEW OF LITERATURE

2.1 Introduction:

A review of the literature on the teaching of mathematics over the past thirty years suggests that more criticism has been directed at elementary school mathematics than at any other level. The attack has been focused on two major curriculum reform movements, commonly referred to as the "meaningful arithmetic" which began in the 1930's and extended into the '50's, and the "modern mathematics" beginning in the late '50's and extending into the early '70's. These reforms were followed by the "back-to-basics" movement of the '70's which resulted in a rethinking of what constitutes "basic" for today's child in mathematics.

Based on the results of the two math assessments of N.A.E.P. (1976, '77), the Euclid Conference of N.I.E. (1975), the N.I.E. - N.S.F. Conference (1976), the N.C.S.M. Report (1977) and the N.C.T.M. PRISM Project (1980), the N.C.T.M. has published its Agenda for Action, which proposed eight "Recommendations for School Mathematics in the 1980's". Of special interest to this study are the first three recommendations:

No. 1 Problem solving be the focus of school mathematics in the 1980's;

No. 2 Basic skills in mathematics be defined to encompass more than computational facility;

No. 3 Mathematics programs take full advantage of the power of calculators and computers at all grade levels.

2.2 Problem Solving

It is impossible to summarize the major findings of studies in "problem solving". Literature reviews are exhaustive; they focus on characteristics of word problems, characteristics of learners, and problem solving strategies. (Polya, 1945; Krutetskii, 1963, '69, '76; Kilpatrick, 1969, '78; Kantowski, 1974; Nelson, 1975, '77; Krulik, 1980.)

Problem solving is an all-encompassing term, but the three most common interpretations, as identified by Branca in the N.C.T.M. 1980 Year Book are: 1) as a goal 2) as a process 3) as a basic skill. In this study, problem solving is interpreted as a basic skill and the following operational definition is suggested:

> A problem is a situation in which an individual or group is called upon to perform a task for which there is no apparent algorithm or means to solve the problem.

Such a definition leads to Krulik's statement of problem-solving as

> "... the means by which an individual uses previously acquired knowledge, skills, and understanding to satisfy the demands of an unfamiliar situation." (p.4)

In summary, although there is little agreement as to the definition of the terms: 'problem' and 'problem solving', most educators agree that the primary goal in teaching mathematics is "problem solving". E. G. Begle in Critical Variables in Mathematics

Education (1979) stated "the real justification for teaching mathematics is that it is a useful subject, and in particular, that it helps in solving many kinds of problems", (p.143).

2.3 Use of Calculators

Just as the literature reveals a wealth of studies on problem solving, so more recent research has focused on many aspects of calculator use in the teaching of mathematics. The major issue of whether or not calculators should be used appears to have been resolved and is now replaced by such questions as: When should they be introduced? Under what circumstances should they be used? What are the discernible implications in mathematics programs?

Bell, Estey et al. state in the N.C.T.M. 1977 Year Book: "Surely no other device, whether designed as an aid to learning or not, has had more potential for influencing instruction in mathematics.", (p.224).

E. G. Begle reported in his "Findings from a Survey of the Empirical Literature" in Critical Variables in Mathematics Ed., (1979):

> "In about half of the studies, the use of hand-held calculators resulted in improvement in student achievement (Computational Skills). In almost all these studies, the calculator was used merely as a supplement to a regular course. We have yet to see the results of evaluation of instructional programs which explicitly make use of the special capabilities of calculators." (p.114).

In the Review of Educational Research, Spring, 1980, Vol. 50, Dennis Roberts examines the impacts of calculators on mathematics - related achievement and attitudes. At the elementary level, he reports that the majority of investigations reported from 1973 to 1978 showed computational advantages, but support for conceptual benefits was minimal. Regarding attitudinal benefits,

> "there seems to be evidence that calculators influence immediate and specific attitudinal perceptions, but evidence supporting more general and lasting changes is not available" (p.85).

2.4 Calculators and Problem Solving

A survey of Marilyn Suydam's Categorized Compilation of References indicates that only a small percentage of the research deals with the use of calculators in the elementary school classroom and an even smaller percentage with the use of calculators in problem solving. This is supported by Roberts in his identification of specific areas of future research. He states:

> "until investigators use calculators as a strategy for solving problems, the concept - formation benefits of calculators will still be an unresolved issue." (p.85).

He noted also the need for investigation "as to the critical timings ... for entering calculators into the mainstream of quantitative instruction." (p.95).

In Wheatley's study (1980), support was found for her suggestion

"that a calculator has a positive influence on children's problem-solving performance." (p.331).

2.5 Summary:

With word processors beginning to replace typewriters, home computer television screens competing with daily newspapers, talk-back computer terminals becoming more common, it is inevitable that the most important requirement of such an exploding information society will not be the acquiring of knowledge, but the ability to use it. We must recognize that the future for five-to-eleven year olds will mean more than the replacement of scratch pads with calculators.

Curriculum developers recognize that calculators are readily available to children in their homes and many excellent resources have been developed for their use in the classroom. But developments have been on a piecemeal basis and have often stressed computational skills rather than problem-solving strategies; no global curriculum changes have taken place which acknowledge the place of the calculator in the classroom because, with the exceptions noted in sections 3 and 4, little empirical research exists as to the effectiveness of the calculator in various aspects of math teaching.

In summary, the present study was designed in order to resolve some of these concerns and specifically to integrate the two major emphases of mathematics for the '80's - the use of calculators in

the development of problem solving skills in elementary school mathematics.

The calculator is with us. How to use it to help children learn and enjoy mathematics is the real challenge.

3. DESIGN AND IMPLEMENTATION

3.1 Selection of subjects

The study was conducted in four classes: a Grade 3 and a Grade 5 in each of two schools. These two levels were selected for the following reasons:

a) For most children, they represent different developmental stages in the child's cognitive growth.

b) At these levels the children are reasonably proficient in the basic computational skills.

c) The same children would be available in the same school should a follow-up study be desired during the subsequent year.

The two schools were chosen for the investigators to study. They were located in the same area of the city and were assessed to be composed of children of the same general ethnic and socio-economic backgrounds. The selection of subjects was naturalistic rather than randomized in that classes were selected according to the willingness of their teachers to co-operate in the study. Although no teacher had had any previous experience with calculators, the two teachers in one school had indicated a willingness to introduce them to their children. This school became the experimental (calculator) group, and the other was referred to as the control (non-calculator) group. Both schools followed the same mathematics

curriculum guidelines and both used the same basic text series: Investigating School Mathematics.

A summary of the numbers involved in each group is shown in Table I.

Table I Subjects involved in study

Grade	Calculator	Non-Calculator
3	29	22
5	28	28

3.2 Instrumentation

The basic design was experimental including two treatment groups at each grade level with pre- and post-testing. The pre-testing was conducted during the last week of November and consisted of the Canadian Test of Basic Skills, Form 3M Mathematical Skills Package, comprising Test M-1 (Concepts) and Test M-2 (Problems). These CTBS tests have well-established norms and this instrument was included so that a statistical analysis of the results could be conducted. It should be noted that these tests do not necessarily reflect the specific objectives outlined in the P.S.B.G.M. elementary school mathematics programs nor the specific classroom activities of the two schools, but they are tests of general achievement in mathematics.

Examination of test M-2 showed that only two of the seven basic problem solving skills identified in this study were evident: those of computation and word problems. It was therefore thought necessary to include an extra problem quiz including a wider variety of skills, to be written in approximately thirty minutes. This, along with a short attitude scale, was conducted early in January. (Appendices A and B.)

In mid-May, both schools wrote post-tests corresponding to the pre-tests; namely, the CTBS Form 4M Mathematical Skills Package, Tests M-1 and M-2; a battery of experimenter-devised problems designed to assess attainment of the seven problem skills (Appendix C) and the attitude scale. The control groups which had answered a four-point attitude pre-survey, were given the five-point post-survey.

3.3 Treatment

Total treatment time for problem-solving skills was sixteen weeks and for calculator usage it was six weeks, although it seemed that in one class this was concentrated into the last two weeks. The investigators' original intent was that the calculator-treatment should be of twelve weeks duration, but the teachers reported illness, holidays and extra-curricular pressures as confounding factors.

Packages of problems exemplifying the seven basic skills were

delivered to all teachers in mid-January, and further sets were delivered at approximately two-week intervals until the end of the study. In addition, the experimental school received calculator-related problems along with calculators for all children in mid-February. Further problems were delivered at two-week intervals.

As part of the study's design, no specific instructions regarding problem solving were distributed, but suggestions and guidelines were provided, (Appendices D and E) as well as extra sources of problems. General instructions concerning the use of calculators and ways of introducing them to children were offered in the form of Worktexts (by Immerzeel and Reys). The one specific request made of teachers was the completion of a record sheet for each of the sets of problems worked. (Appendix F.)

3.4 Treatment of data

- CTBS tests were hand scored and norms were calculated from the information supplied by the publishers (Thos. Nelson & Sons, Canada, Limited)
- Problem pre- and post-tests were scored on a three-point scale where:

  2 = correct answer
  1 = partially correct or some evidence of correct thinking
  0 = no attempt or no evidence of correct thinking

Because the pre- and post-tests contained different numbers of questions, the average score was calculated for each child's test. Thus a child could score between 0,0 and 2,0 on each problem quiz.

- The attitude scale items were designed to be answered "yes, no or sometimes", and they were graded according to a scale where:

  3 = yes
  1 = no
  2 = sometimes

Pre- and post-test results in these three areas (CTBS, problems, attitudes) were analysed by establishing cross-tabulations, by running T-Tests and by performing an ANOVA, where such analyses seemed relevant. This determination was performed using the SPSS (Statistical Package for the Social Sciences) and MUSIC (McGill University System for Interactive Computing), both well-validated systems available in the McGill University computer system.

The results of the statistical analyses are presented in the next section.

4. ANALYSIS AND INTERPRETATION

4.1 Limitations of Study

Caution must be exercised in interpreting the results of any study which is limited in scope and number of subjects. While the schools in this study were chosen to be as alike as possible, only one method was employed per school. There is therefore a possibility that method was confounded with teacher. Only two variables were considered; those of subject and treatment. Some other possible variables may be listed as follows:

a) Teacher. When any new strategy is introduced in a classroom, teacher effectiveness, teacher style - including attitude and enthusiasm - are variables.

b) Instructional strategy. There was a wide range of use of both materials and calculators. It was considered important in a pilot study to explore general possibilities of strategy rather than to impose inflexible guidelines.

c) Treatment Time. It has already been stated that the treatment time was insufficient. Further, there was a great variety in the time employed for the study in each class. (15 - 25 hours) Again, this was allowed in the pilot study so that individual teachers could adapt the project to the class program. It was also important not to give cause for possible debilitation of the children's mathematics achievement by decreasing the time available for the regular mathematics program.

4.2 General Results

An extensive statistical analysis removes a fear expressed by many teachers and parents: that children's computational skills and achievement will be adversely affected by the use of calculators. In general, the analysis has suggested the type of statistics that might be applied productively in a large scale study on this subject. At best, some tentative answers may now be offered to the questions implied in the four general objectives which guided this pilot study.

4.3 Objective 1: Improving problem solving strategies through the use of calculators.

While all results are not statistically significant at 0,05 level or beyond, Table II, on page 17, shows that at the Grade 3 level, the calculator group did slightly better on the experimenter-designed problem solving post-test for questions 1, 2, 4, 6, 7 and 8 and less well on questions 3 and 5. (Appendix C) This evidence produces an answer to the main research question by indicating that at the Grade 3 level, the calculator facilitated the development of five of the seven basic skills identified in this study, namely:

- practice in computation (question 1)
- identifying patterns (question 2)
- choosing operations in multi-step problems (question 4)
- restating problems with irrelevant information (question 6)
- organizing information in lists (question 7)
- planning a strategy (question 8)

Table II Percentage of (Correct & Partially Correct) Answers

Problem	Grade 3				Grade 5			
	Calc.		Non-Calc.		Calc.		Non-Calc.	
	M	*F*	*M*	*F*	*M*	*F*	*M*	*F*
1	42		34		48		46	
	32	*52*	*40*	*28*	*50*	*46*	*43*	*50*
2	54		44		44		46	
	48	*60**	*52**	*36*	*46*	*41*	*47*	*45*
3	20		34		34		36	
	*12**	*28*	*40**	*28*	*29*	*41*	*32*	*41*
4	32		28		42		44	
	32	*32*	*40*	*16*	*39*	*45*	*43*	*45*
5	4		12		32		34	
	8	*0*	*24*	*0*	*32*	*32*	*32*	*36*
6	40		* 38		46		42	
	*36**	*44*	*48**	*28*	*43*	*50*	*46*	*36*
7	48		40		38		44	
	40	*56*	*46*	*32*	*39*	*36*	*39*	*50*
8	46		42		42		40	
	44	*48*	*52*	*32*	*36*	*50*	*36*	*45*
9	N/A		N/A		50		48	
					50	*50*	*47*	*50*

The only values having chi-square less than 0,05 are those marked *. These may not be taken as statistically significant since they have too many empty cells to be reliable.

The two skills which were not improved through the use of the calculator were:

- guess and test (question 2)
- restating problem with missing information (question 5)

Possible reasons for the lack of improvement in these two skills might be: inappropriateness of these skills for calculator usage; insufficient attention given to these topics in both the regular program and treatment phase; inappropriateness of reading level for these children.

These Grade 3 results should consider the dramatic difference between the two classes, as shown by the CTBS results in Table III.

Table III M1 (Concepts)

Grade	CTBS Norms			CTBS Results			
	Pre	Post	Diff.	School	Pre	Post	Diff.
3	32,5	39,5	7,0	Calc.	35,9	41,0	5,1
				Non-Calc.	41,3	47,3	6,0
5	52,5	59,0	6,5	Calc.	54,5	62,4	7,9
				Non-Calc.	55,8	62,5	6,7

From these results, it could be assumed that the non-calculator group may have had higher ability; thus is could be argued that the

calculator may have had a more positive effect on the calculator group than the results indicated.

At the Grade 5 level, the results of the two groups were fairly evenly matched; that is, the calculator apparently made little difference in the development of the seven basic skills.

The results of the CTBS problem test at Grades 3 and 5 levels are presented in Table IV.

Table IV M2 (Problems)

Grade	CTBS Norms			CTBS Results			
	Pre	Post	Diff.	School	Pre	Post	Diff.
3	32,5	39,0	6,5	Calc.	38,2	44,3	6,1
				Non-Calc.	45,4	50,8	5,4
5	51,5	58,5	7,0	Calc.	55,9	64.1	8,2
				Non-Calc.	54,9	60,0	5,1

The results indicate that both calculator classes - Grade 3 and 5 levels - showed a greater rate of achievement than did the non-calculator groups. More specifically, the Grade 5 calculator class showed the greatest improvement in the CTBS problem test. But what must be noted here is that the problems presented were the standard text-book one-step word type.

4.4 Objective 2: Determining the most effective timing for introducing calculators.

It is difficult to offer even tentative suggestions based on these results. It would be presumptuous to suggest any firm recommendations from a pilot study.

CTBS results in Tables III and IV show that both Grade 3 classes improved less than the CTBS norms would suggest as possible in the "Concepts" test, but the Grade 3 calculator group improved more in the "Problems" test.

Both Grade 5 classes improved more than the CTBS norms in the "Concepts" test, and in the "Problems" test, improvement was greater in the calculator group. In each case, the improvement is reported in months, so that a "difference" of 6,5 represents 6½ months of instruction during the school year.

Although this indicates that greater improvement in achievement, as shown by CTBS results, was in the Grade 5 calculator class, it will be shown in Table V that the Grade 3 calculator class showed greater enhancement of attitude than Grade 5.

4.5 Objective 3: Enhancing student interest in mathematics as a result of using calculators.

The responses to the attitude pre-survey (see Appendix B) were cross-tabulated with the attitude post-survey for each of the four

groups and then for male and female respondents within each of the four groups. Table V summarizes the results of these cross-tabulations.

Table V Results of Attitude Pre-Test and Post-Test Cross-Tabulations

Class	Grade 3				Grade 5			
	Calc.		Non-Calc.		Calc.		Non-Calc.	
Male / Female	M	F	M	F	M	F	M	F
1. Math is my favourite subject at school	0 / (+)	0	(+) / (+)	0	(+) / 0	0	0 / (-)	0
2. I enjoy solving the problems in my text-book	(+) / 0	(+)	+ / (+)	(+)	0 / 0	0	0 / (-)	(+)
3. I like to work at math puzzles & brain-teasers when I have time.	+ / +	+	+ / +	(+)	0 / 0	0	(+) / 0	(+)
4. I enjoy working with large numbers and long columns of numbers	- / (-)	-	0 / 0	0	0 / 0	0	0 / 0	0
5. I use a calculator at home.	(-) / 0	0	N.A.		0 / 0	0	N.A.	

\+ = improved attitude
\- = worsened attitude
0 = no change
( ) = slight change
N.A. = not applicable

No definite pattern emerges from this section of the survey, except that the calculator had no effect on the attitude towards mathematics of the fifth grade class. Whether this is due to the calculator, or to the age of the children, or to some entirely different variable, would be impossible to determine without a larger sample or a more complex instrument.

All groups excepting Grade 5 calculator class demonstrated an improvement in their attitude towards "puzzles and brainteasers" (question 3) and both Grade 3 classes declared increased enjoyment in problem solving. (Both these responses may owe as much to the Hawthorne effect as to anything else.)

4.6 Objective 4: Identifying possibilities for further investigations.

It was not intended that the results of the study would have immediate application in the classroom. It was hoped rather that results might influence current thinking about problem solving and calculators, and ultimately have important implications for classroom practice.

Clearly, there is evidence of the need for additional investigation. Questions which can be raised from this study include the following:

a) What are the characteristics of good problems and problem situations for elementary school children?

b) What are the characteristics of good problem solvers?

c) What are effective problem solving strategies in elementary school mathematics?

d) What kind of instrumentation should be used to measure performance in problem solving? (paper and pencil tests as well as protocol analysis.)

e) When and under what circumstances should calculators be introduced to young children?

f) How can the present mathematics curriculum be modified and curricular materials be improved to reflect the mathematics' needs of the '80's?

g) How can current classroom practices in the teaching and learning of problem solving be improved?

5. SUMMARY AND RECOMMENDATIONS

5.1 Summary

Concern over the impact of calculators in elementary school mathematics prompted this study of the use of calculators in the development of certain basic skills of problem solving. Based on the results and limitations of the study, the following conclusions seem warranted:

5.1.1 The use of calculators has not adversely affected children's computational skills and achievement.

5.1.2 Calculators have a positive influence on children's problem solving performance in general.

5.1.3 In solving problems which involved the seven basic skills identified in this study, the calculator was more effective at the Grade 3 level, and specifically more effective in developing certain of these skills than others.

5.1.4 The greatest improvement in achievement in solving the standard text-book word problems, as shown in the CTBS results, was in the Grade 5 calculator class.

5.1.5 Increased enjoyment in problem solving was reported in both Grade 3 classes, while the enhancement of attitude was greater in the Grade 3 calculator class than Grade 5.

5.1.6 All classes, with the exception of Grade 5 calculator, indicated an improvement in attitude towards "puzzles" and "brainteasers".

5.2 Recommendations

Although the results of the pilot study do indicate support for the use of calculators in developing certain basic skills in problem solving, there is evidence that further investigations are needed. Possible questions have been provided in a previous section (4.6). If additional studies are undertaken, the following considerations are suggested:

5.2.1 A study of longer range should include a greater number of subjects, more extensive treatment and such variables as teacher and instructional strategy.

5.2.2 Implementation of the design should include: an initial meeting where the study and expectations are fully outlined; an orientation program where in-service sessions on "problem solving" and "calculator usage" are presented; clear understanding of teacher's role; specific procedures for instruction and testing; detailed schedule of dates.

5.2.3 Sources of data should include tests: pre and post; standardized (revised CTBS) as well as local (P.S.B.G.M.); problem solving; attitudinal scales (children and teacher); retention, as well as clinical methodology to record problem solving behaviors (as in protocol analysis).

5.2.4 In addition to the investigator who would co-ordinate the project, trained personnel would be required to provide in-service sessions, prepare materials, observe and interview subjects, and keep careful records of observations.

5.2.5 Curriculum should be modified to include greater emphasis on problem solving (in mathematics as well as other areas), estimation, probability and statistics, and decreased emphasis on such topics as computation of 4 - 5 digit numbers, (unless calculators are used), fractions and bases other than ten.

5.2.6 Appropriate problem solving- and calculator-based instructional materials must be made available (commercially or locally developed).

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APPENDIX A

Problem Pre-Test: Grade 3

Problem Pre-Test: Grade 5

PRE-TEST

PROBLEMS

Grade Three

Your Name_____

See if you can write the answers to these mindbenders in the circle at the end of the question.

1. How many hours do you think you have spent in your life so far?

2.

1 xx	2	3	4	5 xx	6	7	8	9 xx	

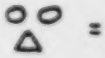
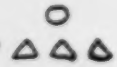
Will there be an xx in box 19?

3. 2, 4, 8, __, __, 64.

What are the missing numbers?

4. What numbers belong in the three empty circles?

$$\begin{array}{r} \bigcirc\ 2\ 5 \\ 6\ 4\ \bigcirc \\ +\ 1\ \bigcirc\ 8 \\ \hline 1\ 4\ 7\ 5 \end{array}$$

5. If = 12 and  = 21,  =

PRE-TEST PROBLEMS

Grade Five Your Name_____

Try these mindbenders!

Write your answer in the circle at the end of the question.

1. How many hours do you think you have slept in your life so far?

2. How long is one million seconds? Is it:

   a) 1½ years
   b) 11½ years
   c) 46 hours

3. What is the next number in this series?

   3, 7, 15, 31, ___.

4. If is 358 and is 106,

   what is ?

5. Here is a restaurant menu:

hamburgers	.90		
cheeseburgers	.95		
hot dog	.60		
cheese-dog	.70		
French fries	.40	or	.55
milk	.45	or	.60
milk shakes	.95		

   How many different lunches could you buy if you could spend $3 or less?

APPENDIX B

Attitude Scale: Pre-Survey

Attitude Scale: Post-Survey

NAME: _____ SCHOOL: _____

GRADE: _____ DATE: _____

	YES	NO	SOMETIMES
1. Math is my favourite subject at school.			
2. I enjoy solving the problems in our text book.			
3. I like to work at math puzzles and brainteasers when I have time.			
4. I enjoy working with large numbers and long columns of numbers.			

NAME: _____ SCHOOL: _____

GRADE: _____ DATE: _____

	YES	NO	SOMETIMES
1. Math is my favourite subject at school.			
2. I enjoy solving the problems in our text book.			
3. I like to work at math puzzles and brainteasers when I have time.			
4. I enjoy working with large numbers and long columns of numbers.			
5. I use a calculator at home.			

APPENDIX C

Problem Post-Test: Grade 3

Problem Post-Test: Grade 5

1981 - 05 - 08 POST-TEST

Grade Three PROBLEMS Name: _____

1. Find the number that is missing:

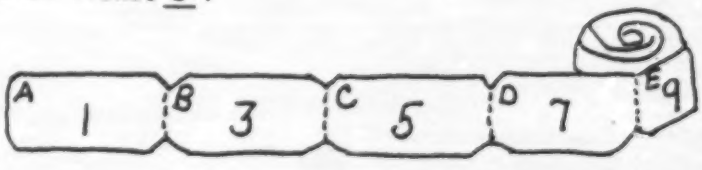
46	38	26
29		48
35	39	36

Work:

Answer: _____

2. What number will be printed on Ticket Z ?

Work:



Answer: _____

3. When I multiply my age and my older brother's age, the number I get is 143. How old am I?

Work:

Answer: _____

4. About how many meals have you eaten in your life so far?

Work:

Answer: _____

5. (a) Chico and George are selling lemonade at 25¢ a glass. How much money will they make in a week?

Work:

Answer: _____

5. (b) Maria went with her father, mother and three brothers to Macdonald's for a snack. This was the menu:

cheeseburger	$0,95		
hamburger	,90		
french fries	,40	or	,55
milk	,45	or	,60
milkshake	,95		

How much did Maria's father pay if everyone ordered a hamburger and a milkshake?

Work:

Answer: _____

6. Gino works in an ice cream store where ice cream sells for 40¢. Show all the ways Gino can be paid using dimes, nickels and pennies.

Work:

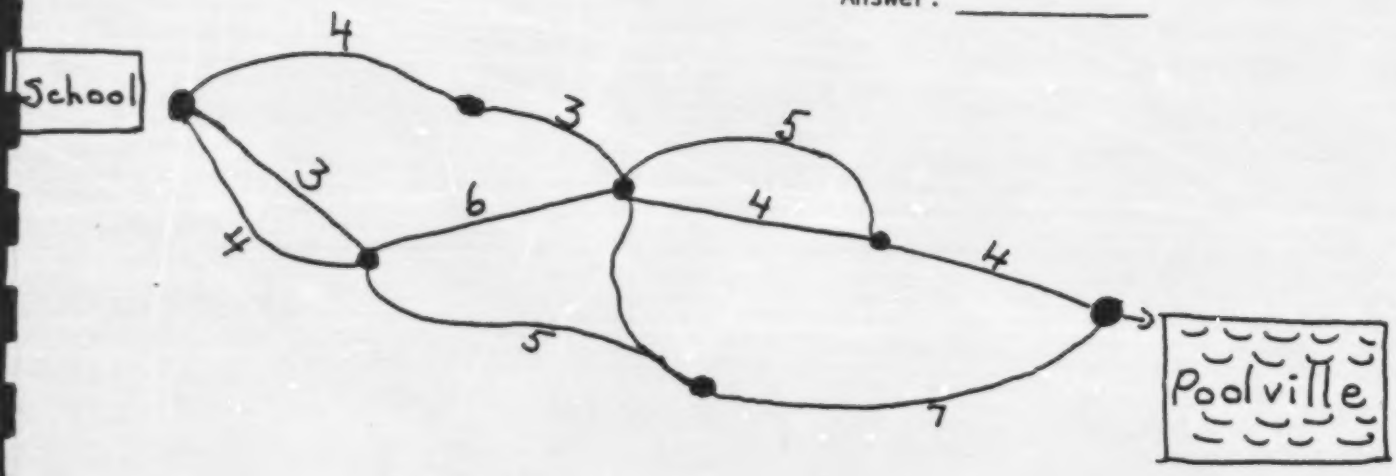
Answer: _____

7. Show the shortest route from school to the pool.

How many kilometres is it?

Work:

Answer: _____



1981 - 05 - 08 POST-TEST

Grade Five PROBLEMS Name: _____

1. Fill in the missing number:

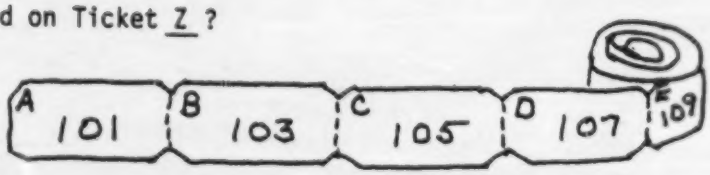
Work:

4276	2834	2687
1685		5400
3836	4251	1710

Answer: _____

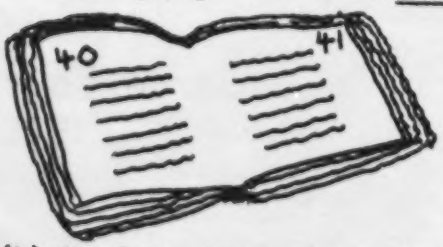
2. What number will be printed on Ticket Z ?

Work:



Answer: _____

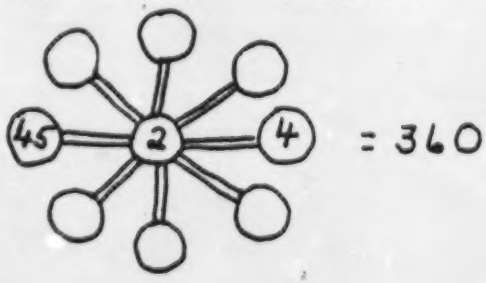
3. (a) The product of these two facing pages is 40 x 41 or 1640. Where would you open the book so the product of the two facing page numbers is 9702?



Work:

Answer: _____

3. (b) Complete the wheel by filling in the circles with the numbers 3, 6, 9, 20, 30, 60. The product of the three numbers in a line must be 360.



4. (a) A whale's heart beats about 9 times a minute. About how many times does it beat in May?

Estimate: _____

Work:

Answer: _____

4. (b) Roberto was paid $9,50 per week for delivering papers. How many weeks does he have to work to be able to buy a 10-speed bike costing $135,00?

Work:

Answer: _____

If Roberto starts work on May 1, when will he be able to buy it?

July 1 _____ August 1 _____ September 1 _____

5. The prices of baseball tickets at Olympic Stadium are $8,25 for the blue seats, $7,00 for the red seats and $4,00 for the green. There are 69 000 seats in all. How much will it cost to buy 15 blue tickets and 35 green ones?

Work:

Answer: _____

6. How many ways can Sonia be paid her allowance of $1,60 if she receives only quarters and nickels?

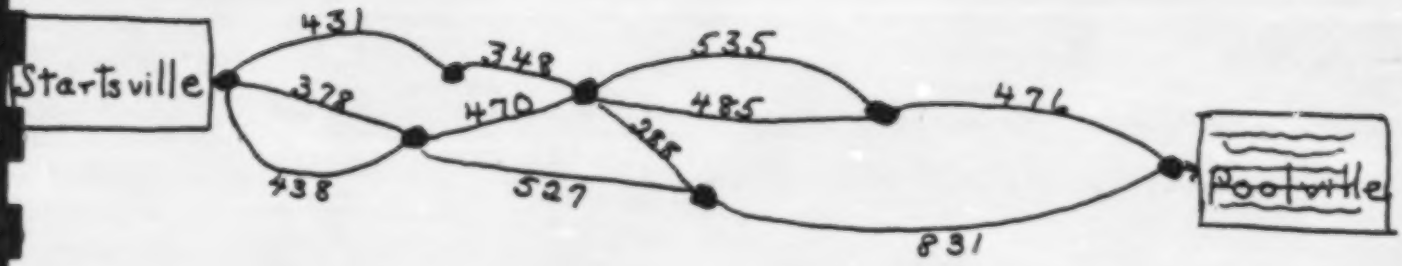
Work:

Answer: _____

7. Show the shortest route from Startsville to Poolville.

   How many kilometres is it?

Answer: _____



APPENDIX D

Teacher Memos

1980 - 11 - 14

THE PROTESTANT SCHOOL BOARD OF GREATER MONTREAL

SCHOOL RESEARCH PROJECT

PILOT STUDY

QUESTION: Which aspects of 'problem solving in elementary school mathematics' can be developed through the use of calculators?

PROBLEM CATEGORIES:

PROBLEM SOLVING STRATEGIES:

EVALUATION:

MATERIALS:

Shirley McNicol
Faculty of Ecucation
McGill University
Tel. - Office: 392-8822 or 8898
Home : 935-5925

Kate Le Maistre
Research Assistant
Tel.: 453-2021

Meeting: 80-11-14

1981 - 02 - 05

PROTESTANT SCHOOL BOARD OF GREATER MONTREAL PILOT STUDY ON PROBLEM SOLVING WITH CALCULATORS IN ELEMENTARY SCHOOL MATHEMATICS AT LEVELS 3 AND 5.

It was hoped that the period from November to April would be available for the problem-solving and calculator sections of the study. A delay in obtaining the CTBS tests has resulted in this modified "time-line". To allow adequate time for work with the calculators to be meaningful, the children should have the calculators by March 9th.

Phase 1 Jan/Feb	Introduction to Problem Solving
Phase 2 February	Introduction to Calculators
Phase 3 Mar/Apr/May	Application and Feedback
Phase 4 May	Evaluation (Post-test: middle week of May)
Phase 5 June	Analysis and report (To be given to Instructional Services before submission to Board)

Since you will be responsible for the safe return of the calculators at the end of the study, would you consider the following:

1. Have each child label his/her own calculator with his name.
2. Allow the children to use the calculators at any time during the school day that seems appropriate.
3. Keep the calculators in school, preferably in the classroom where you have control over them.

Kate Le Maistre, for Shirley McNicol.

1981 - 03 - 16

The Protestant School Board of Greater Montreal

SCHOOL RESEARCH PROJECT

PILOT STUDY

Title: Problem solving with calculators in Elementary School Mathematics

Question: Which aspects of "problem solving in elementary school mathematics" can be developed through the use of calculators?

Schedule:

Phase 1: Nov. - Dec.:	Pre-test
Phase 2: Jan. - Feb.:	Introduction to Problem Solving (Introduction to Calculators)
Phase 3: Mar.-Apr.-May:	Application & Feedback
Phase 4: May 11-15:	Post-test
Phase 5: May 18-22:	Analyses
Phase 6: June:	Report

Problem Solving Skills

Our preliminary review of the children's work has confirmed what you have already observed - that some children are able to solve all the problems without much help while others need considerable help. Now that the introductory phase of the project is over, it seems appropriate to begin helping all the children develop the following skills which are needed in problem solving situations.

1) Practice in computation;

2) Identify patterns and decoding;

3) Guess and test; estimate; round off;

4) Choose operations in one-step word problems, two-step and multiple-step;

5) Restate problems with missing or irrelevant information;

6) Organize information: pictures, diagrams, lists, graphs, models, experiments;

7) Plan a strategy.

Project Procedures:

a) Hand out a problem sheet and allow time for the children to solve the problem in any way they choose. All their work, including estimates, trials and solutions should be shown on the sheet.

b) For those children who are not successful at this stage, refer to the sheet of "Possible Strategies", and use as many of the suggestions as you need.

c) Discuss and check the solutions, and then record results on the "Record Sheet".

d) If you think it's necessary, provide extra practice by giving additional, similar problems.

e) Encourage the children to write their own problems and distribute these for others to solve.

Reminders:

1. Check the pages: "Guidelines for use of folder", and "Possible Problem Solving Strategies".
2. Use the record sheet for each problem, both those we have given you and any others (yours and the children's).
3. Use "Estimation" wherever it is appropriate.
4. Continue to add children-devised problems.
5. List any additional sourcebooks you find useful.

Sincere thanks for your cooperation and assistance.

Shirley McNicol,
Tel.: 392-8822 (Office)
935-5925 (Home)

81-03-16

1981 - 04 - 27

The Protestant School Board of Greater Montreal

SCHOOL RESEARCH PROJECT

PILOT STUDY

Title: Problem solving with calculators in Elementary School Mathematics

Schedule:

Phase 1:	Nov. - Dec.	: Pre-test
Phase 2:	Jan. - Feb.	: Introduction to Problem Solving (introduction to calculators)
Phase 3:	Mar.-Apr.-May	: Application and Feedback
Phase 4:	May 11 - 15	: Post-test
Phase 5:	May 18 - 22	: Analysis
Phase 6:	June	: Report

To: _____ Grade: _____, School: _____

Enclosed are the final 'problems' which will complete the seven categories of skills mentioned in my previous memo of 81-03-16. (These supplement examples in your folder.) I would hope that all children will have an opportunity to work these before the test which is scheduled for _____.

Thanks again for your assistance.

Shirley McNicol

81-04-27

APPENDIX E

Suggested Guidelines

1981 - 01 - 13

Some Guidelines for use of this folder

1. Use any, or all, of the problems suggested, and in any order.

2. Don't feel that all students must work every problem.

3. Use your own problems, those that appear in newspapers, arise from class discussion, and invented by students.

4. Encourage students to develop - and describe - their own strategies for solving problems.

5. Ask the students to rate the problems by drawing a happy face or a sad face, or by some other method.

   e.g. I liked this one

   I didn't like this one

6. Jot down notes of difficulties, solutions, comments... anything that seems interesting.

7. Keep copies of students' own problems as well as your own, if possible. Try to return a problem deck that is bigger than when you received it!

8. Trade sets of problems, if they seem quite unsuitable for your class.

1981 - 02 - 17

Some Possible Problem-Solving Strategies

(after Imerzeel)

1. GETTING TO KNOW THE PROBLEM

A. Can you read the problem?

B. Can you pick out the important information?

C. Can you tell what you need to find out?

D. Can you think of a problem like this that you have solved before?

2. DECIDING WHAT TO DO

Would any of these actions help you to solve the problem?

- compute
- make a list
- make a table
- write an equation
- draw a picture
- make a diagram
- make a guess
- collect information
- perform an experiment
- make a graph
- make a model
- make a simpler problem

3. DOING IT

Can you carry out the action you decided on?

Estimate first, then try to write a mathematical sentence.

4. THINKING ABOUT WHAT YOU HAVE DONE

A. Does your answer meet the conditions of the problem?

B. Does the answer seem reasonable?

C. Now that you have the answers, how would you help someone else to solve the problem?

D. Can you write another problem that would be solved in a similar way?

APPENDIX F

Record Sheets

1981 - 01 - 13

Initial Report Sheet

Difficulty:- Too easy: Too hard: About right

Children's Interest:- High: Low

Amount of help from teacher:- Much: Little: None

Steps taken by children in solving problem:-

Questions asked by children:-

Your comments:-

Do you want any more like this? Yes: No

1981 - 03 - 16

Record Sheet

Problem Solving Skill: Grade: _____

School: _____

_____ Date: _____

Difficulty:	too hard	too easy	about right
Children's Interest:	high	low	
Amount of help needed:	much	little	none

Number of children attempting this problem: _____

Number of correct answers: _____

Questions raised by children:

Your comments:

APPENDIX G

Samples of Pupil Problems

A suggestion was made to teachers that they ask pupils to write their own problems, using large numbers.

Following are selected ones written by children in Grade 3 (pages 60 to 63) and Grade 5 (pages 64 and 65).

Election Day

Three parties

Mr. Trudeau 300 votes

Mr. Clark - 1.666 votes

Mr. Levesque 100 votes

Prime Minister needs 2.452 votes

1. Who is most likely to win election?

By Natasha Netochay
Gr. 3 Rm. 6

2. How many more votes does the runner up need?

Hockey Penalties Jerry

Guy Lafleur had 2 penalties and Bobby Clarke had 7 penalties, 2 minutes for one penalty? How many more minutes does Bobby Clarke have than Guy Lafleur?

Ivana Monday March 30, 1981

Short story problem

Joise had $5.90. She wanted to buy a doll. The doll costed $1.50. Then she decided to by a doll dress and doll house, the doll dress costed 69¢ and the doll house costed $2.75. How much did it cost Joise for everything? And how many did she have left?

Problems solving

1. Jane went to the store. She had 35¢ and she spent 5¢. How much does she have left?

2. A family went to a trip to Québec. They were 5 people. The tickets for the train cost $10.00 each. How much did the pay?

from Pak Mulé

Fishing

Rob went fishing. He had 20 worms. While fishing, 5 worms fell off the hook.

a) How many fish did he catch?

b) Write on another paper what you think Rob would do with the fish.

by Natalie Pasieka

If you can eat a cookie a day. How much cookies can you eat in 8 years.

Tanya Mlynek

8. Estimate how many hairs on your head you have.

Carolyn O.

Your mother had to pay a bill of one thousand dollars in a month and she only had one hundred dollars how much money would she need ans. 900

2. 400
90
+450
990

DONNA

If there was a language party and was 400 french people, 90 english people, and 450 spanish people how many people in all ans: 990

ument

If there was 30 people in each class and 8 classes in a school. How many pupils in 12 schools ans_____

Patrick

I, pick a lunch that will cost 2.95.

hamberger $1.15
Milk 95¢
icecream $1.95
cake- 40¢
Pie- $1.00
cand ¢5